Brain Computer Interaction

Institute Elective

L-T-P-C: 2-1-0-3

1. Course Objectives:

The objective of this course is to equip students with the knowledge of various methodologies and technologies used to collect information from the brain and learn about their applications and enable them to further pursue this emerging topic as a career option.

2. Syllabus:

Unit – 1 [3 Hours]: *Introduction to Brain Computer Interface* - Definition and overview of BCI - History of BCI - Application of BCI in medical and non-medical fields.

Unit – 2 [3 Hours]: *Introduction to Basic Neuroscience* - Synapses and neurons; Working of the brain and its various lobes; Neural mechanisms- transfer of neuronal information.

Unit – 3 [9 Hours]: *Modelling and Recoding of the Brain Signals*- Brain computer interface types - Invasive, Semi-invasive, Non-invasive techniques; An Introduction to Non-Invasive Acquisition approaches - EEG, MEG, fNIRS, fMRI; EEG and Why EEG ; EEG Hardware-EEG electrode systems, EEG Data Acquisition approaches, Experimental setups, EEG Recording and analysis software; Neural Potentials- ERP, P300, SSVEP, ASSR, SCP, Motor Imagery. analysis softwares - Neural Potentials- ERP, P300, SSVEP, ASSR, SCP, Motor Imagery

Unit – 4 [8 Hours*]: Signal processing* - Biological artifacts; Signal Pre-processing- Epoching, noise removal; Filtering techniques - Temporal and Spatial Filters

Unit – 5 [9 Hours]: *Signal Analysis using Machine Learning Approaches* - Feature Engineering- Feature extraction, reduction, and optimization - Classification and Clustering (Supervised and unsupervised learning of EEG Data)

Unit – 6 [4 Hours]: *BCI Applications* - Cognitive Engineering - Probing mind - Vigilance detection using EEG signals - Mental workload and Cognitive load estimation - BCI in consumer marketing - BCI for lie detection.

3. Course Outcomes:

At the end of the course, students should have the ability:

i) To apply the knowledge of the components of Brain Computer Interface System, its applications in Medical and Non-Medical Fields
ii) To demonstrate the knowledge of basic neuroscience to collect information from the brain and translate the information using advances in neural interfacing and neural imaging technology.
iii) To analyse the commonly used signal processing and machine learning methods and apply these methods on real neural data.
iv) To experience on the recent tools and applications of BCI and ablility to solve BCI problems by working in teams and aware towards the moral & ethical responsibility while using interfacing system.

4. Textbooks:

a) Rajesh P. N. Rao, Brain-Computer Interfacing: An Introduction, Cambridge university press, 2019, ISBN: 978-1108708012.

5. Reference Books:

a) Brain-Computer Interfaces: Principles and Practice, Jonathan Wolpaw (editor), Oxford university Press, 2012
b) Cognition, Brain, and Consciousness: Introduction to Cognitive Neuroscience, Second Edition, Bernard J. Baars, Nicole M. Gage, Academic Press, 2010
c) Bishop, Christopher M. Pattern recognition and machine learning. springer, 2006.

d) Satish Kumar, Neural networks: A classroom approach, Tata McGraw Hill, 2011.
e) J. S. R. Lang, C. T. Sun and E. Mizutaju, Neuro-fuzzy and soft computing, Pearson Education, 1996.
f) David E. Goldberg , Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley, 1989
g) https://sccn.ucsd.edu/wiki/Introduction_To_Modern_Brain-Computer_Interface_Design

6. Course Assessment Plan:

a. Exams (50%)
   i. Mid Term (20%)
   ii. End Term (30%)

b. Quizzes (30%)
   i. Class participation (10%)
   ii. Scheduled Quiz (20%)

c. Assignment (20%)